

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (previously presented) A single crystal silicon segment having two major, generally parallel surfaces, one of which is the front surface of the segment and the other of which is the back surface of the segment, a central plane between the front and back surfaces, a circumferential edge joining the front and back surfaces, a surface layer which comprises a first region of the segment below the front surface and a distance, D_1 , as measured from the front surface and toward the central plane, and a bulk layer which comprises a second region of the segment between the central plane and the first region, the segment being characterized in that

the segment has a non-uniform distribution of minority carrier recombination centers, with the concentration of the centers in the bulk layer being greater than the concentration in the surface layer and with the centers having a concentration profile in which the peak density of the centers is at or near the central plane with the concentration generally decreasing from the position of peak density in the direction of the front surface of the segment and with the concentration generally decreasing from the position of peak density in the direction of the back surface of the segment.

Claim 2 (original) The segment of claim 1 having a carbon concentration which is less than about 1×10^{16} atoms/cm³.

Claim 3 (original) The segment of claim 1 having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 4 (original) The segment of claim 1 having a thickness ranging from about 500 microns to about 800 microns.

Claim 5 (original) The segment of claim 1 having a thickness ranging from about 800 microns to about 1200 microns.

Claim 6 (previously presented) The segment of claim 1 wherein the concentration of minority carrier recombination centers in the surface layer is less than about 1×10^{11} centers/cm³.

Claim 7 (previously presented) The segment of claim 1 wherein the concentration of minority carrier recombination centers in the surface layer is less than about 1×10^{13} centers/cm³.

Claim 8 (original) The segment of claim 1 wherein the distance D_1 is at least about 10 microns.

Claim 9 (original) The segment of claim 1 wherein the distance D_1 is at least about 30 microns.

Claim 10 (original) The segment of claim 1 wherein the distance D_1 is at least about 50 microns.

Claim 11 (original) The segment of claim 1 wherein the distance D_1 is at least about 100 microns.

Claim 12 (original) The segment of claim 1 wherein the front surface is polished.

Claim 13 (currently amended) A single crystal silicon segment containing minority carrier recombination centers and having two major, generally parallel surfaces, one of which is the front surface of the segment and the other of which is the back surface of the segment, a central plane between the front and back surfaces, the recombination centers having a non-uniform distribution between the front and back surfaces with a maximum concentration of the recombination centers being in a region

which is between the front surface and the central plane and nearer to the front surface than the central plane and with a minimum concentration of the recombination centers, which is less than the concentration of the recombination centers at the central plane and which is between the front surface and the maximum concentration, the concentration of the recombination centers increasing from the front surface minimum concentration to the ~~region of~~ maximum concentration and decreasing from the ~~region of~~ maximum concentration to the central plane.

Claim 14 (original) The segment of claim 13 having a carbon concentration which is less than about 1×10^{16} atoms/cm³.

Claim 15 (original) The segment of claim 13 having a carbon concentration which is less than about 5×10^{15} atoms/cm³.

Claim 16 (original) The segment of claim 13 having a thickness ranging from about 500 microns to about 800 microns.

Claim 17 (original) The segment of claim 13 having a thickness ranging from about 800 microns to about 1200 microns.

Claim 18 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 5 microns from the front surface of the segment.

Claim 19 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 10 microns from the front surface of the segment.

Claim 20 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 20 microns from the front surface of the segment.

Claim 21 (original) The segment of claim 13 wherein the maximum concentration of recombination centers is within about 40 microns from the front surface of the segment.

Claim 22 (original) The segment of claim 13 wherein the front surface is polished.

Claim 23 (withdrawn) A process for heat-treating a single crystal silicon segment to influence the concentration profile of minority carrier recombination centers in the segment, the silicon segment having a front surface, a back surface, a central plane between the front and back surfaces, a surface layer which comprises the region of the segment between the front surface and a distance, D, measured from the front surface and toward the central plane, and a bulk layer which comprises the region of the segment between the central plane and surface layer, the process comprising:

heat-treating the segment in an atmosphere to form crystal lattice vacancies in the surface and bulk layers;

controlling the cooling rate of the heat-treated segment to produce a segment having a vacancy concentration profile in which the peak density is at or near the central plane with the concentration generally decreasing in the direction of the front surface of the segment; and,

thermally diffusing platinum atoms into the silicon matrix of the cooled segment such that a platinum concentration profile results which is substantially dependant upon the vacancy concentration profile.

Claim 24 (withdrawn) The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises heating the segment to a temperature in excess of about 1175 °C in a non-oxidizing atmosphere.

Claim 25 (withdrawn) The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises heating the segment to a temperature in excess of about 1200 °C in a non-oxidizing atmosphere.

Claim 26 (withdrawn) The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises heating the segment to a temperature in the range of about 1200 °C to about 1275 °C in a non-oxidizing atmosphere.

Claim 27 (withdrawn) The process of claim 23 wherein said cooling rate is at least about 20 °C per second through the temperature range at which crystal lattice vacancies are relatively mobile in silicon.

Claim 28 (withdrawn) The process of claim 23 wherein said cooling rate is at least about 50 °C per second through the temperature range at which crystal lattice vacancies are relatively mobile in silicon.

Claim 29 (withdrawn) The process of claim 23 wherein said cooling rate is at least about 100 °C per second through the temperature range at which crystal lattice vacancies are relatively mobile in silicon.

Claim 30 (withdrawn) The process of claim 23 wherein platinum atoms are thermally diffused into the silicon matrix of the segment by heating the segment to a temperature ranging from about 670 to about 750 °C.

Claim 31 (withdrawn) The process of claim 23 wherein platinum atoms are thermally diffused into the silicon matrix of the segment by heating the segment for about 10 minutes to about 2 hours.

Claim 32 (withdrawn) The process of claim 23 wherein prior to platinum in-diffusion the heat-treated or cooled segment is subjected to a second heat-treatment in an atmosphere of pure oxygen or pyrogenic steam, the temperature of said second heat-treatment being at least about equal to the temperature of the first.

Claim 33 (withdrawn) The process of claim 23 wherein said heat-treatment to form crystal lattice vacancies comprises the steps of:

(a) subjecting the segment to a first heat-treatment at a temperature of at least about 700 °C in an oxygen containing atmosphere to form a superficial silicon dioxide layer which is capable of serving as a sink for crystal lattice vacancies; and,

(b) subjecting the product of step (a) to a second heat-treatment at a temperature of at least about 1150 °C in an atmosphere having an essential absence of oxygen to form crystal lattice vacancies in the bulk of the silicon segment.

Claim 34 (withdrawn) A process for heat-treating a single crystal silicon segment to influence the concentration profile of minority carrier recombination centers in the segment, the silicon segment having a front surface and a back surface, the front surface having only a native oxide layer present thereon, and a central plane between the front and back surfaces, the process comprising:

heat-treating the front surface of the segment in a nitriding atmosphere to form crystal lattice vacancies in the segment;

controlling the cooling rate of the heat-treated segment to produce a vacancy concentration profile in the cooled segment in which a maximum concentration is between the front surface and the central plane and nearer to the front surface than the central plane, the vacancy concentration generally increasing from the front surface to the region of maximum concentration and generally decreasing from the region of maximum concentration to the central plane; and,

thermally diffusing platinum atoms into the silicon matrix of the cooled segment such that a platinum concentration profile results which is substantially dependant upon the vacancy concentration profile.

REMARKS

A. Status of Claims

Claims 1-34 are pending in the application. Claims 1-22 have been allowed. Claims 23-34 have been withdrawn in response to a restriction requirement. Claim 13 is currently amended. Support for amended claim 13 may be found, for example, at Figure 6D. No new material is added by this Amendment.

B. Patentability of Amended Claim 13

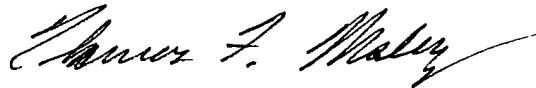
As amended, claim 13 describes a single crystal silicon segment having a distribution of non-uniform minority carrier recombination centers. Specifically, the distribution has a maximum concentration and a minimum concentration. The maximum concentration is located between a front surface of the segment and a central plane of the segment and closer to the front surface than to the central plane. The minimum concentration is located between the front surface and the maximum concentration, and the minimum concentration is less than a concentration of minority carrier recombination centers at the central plane.

Applicant submits a Supplemental Information Disclosure Statement herewith for "Uniformization of the Pt-Induced-Trap Concentration Profile in Silicon by the Two-Step Diffusion Method" by B. Deng et al. The reference discloses a two step diffusion process for uniformizing the depth profile of platinum-trap concentration. Significantly, the process disclosed by this reference produces a non-uniform platinum concentration profile such that the peak concentration is nearer to the surface of a wafer than to the center of the wafer, but the platinum **concentration at the center of the wafer is less than the platinum concentration everywhere else throughout the wafer**. Thus, the reference fails to disclose the concentration profile described by amended claim 13, wherein a minimum concentration between the surface and the maximum concentration is less than the concentration at the central plane.

CONCLUSION

* In view of the foregoing, Applicants respectfully submit that claims 1-22 as amended satisfy the requirements for patentability. Favorable reconsideration and allowance of these claims are therefore respectfully requested. Applicants enclose a Supplemental Information Disclosure and a check for \$750.00 to cover the cost of the Request for Continued Examination filed herewith. The Examiner is authorized to charge any underpayment or to credit any overpayment of the above referenced fees to Deposit Account No. 19-1345.

Respectfully submitted,



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